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# MATH 9901: Introduction to Probability and Statistical Inference

## Module Details

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|---|---|
| **Module Code:** | MATH 9901 |
| **Module Long Title:** | Introduction to Probability and Statistical Inference APPROVED |
| **Banner Title:** | Intro to Prob & Stat Inference |
| **Version:** | 2 |
| **Indicative NFQ level:** | Level 9 |
| **Valid From:** | Sept 2024 ( September 2024 ) |
| **Language of Instruction:** | English |
| **ECTS Credits::** | 10 |
| **Current Coordinator::** | FIONA MURRAY |
| **Module Coordinators:** | • JOHN BUTLER ( 08 April 2024 to 09 April 2024 )<br>• FIONA MURRAY ( 09 April 2024 to --- ) |
| **School Responsible:** | School of Mathematics & Statistics |
| **Campus:** | City Campus |
| **Module Overview** | This module will introduce students to the role of probability models and statistical inference in data analysis. Practical worked examples will give the student experience in applying probability and statistical models to real data. Peer-to-peer learning and mentoring in an on-line environment will be utilised to support students in developing their background and knowledge in this topic. |
| **Learning and Teaching Methods** | The module will be delivered by online lectures and tutorials. |

| **Indicative Syllabus** |
|---|
| **1. Statistical Analysis Overview**<br>1.1) Introduction and orientation, motivation for formal statistical analysis. |
| **2. Data Summary**<br>2.1) Data summary, measures of location and dispersion and their meaning, skew. |
| **3. Probability**<br>3.1) Probability and probability models for data, calculating probabilities. |
| **4. Discrete & Continuous Distributions**<br>4.1) Discrete and continuous distributions, means and standard deviations of probability distributions: Bernoulli, Binomial, Hypergeometric, Poisson, Multinomial and Normal probability distributions. Multivariate Distributions. |
| **5. Hypothesis Testing**<br>5.1) Hypothesis tests, statistical significance, p-values and their interpretation, confidence intervals. |
| **6. Contingency Tables & Tests** |

| |
|---|
| 6.1) Tests applied to contingency tables and independence tests. |
| **7. Linear & Logistic Regression**<br>7.1) Linear and logistic regression models. Predictions and categorisation from regression models. |

| Learning Outcomes | |
|---|---|
| *Upon successful completion of this module the learner will be able to* | |
| **#** | |
| MLO1 | Describe a data set using descriptive statistics. |
| MLO2 | Explain and apply the laws of mathematical probability and conditional probability. |
| MLO3 | Formulate probability models for discrete data. |
| MLO4 | Formulate probability models for continuous data. |
| MLO5 | Perform statistical hypothesis testing. |
| MLO6 | Perform statistical hypothesis testing on contingency tables and independence tests. |
| MLO7 | Formulate, fit and interpret linear regression models. |

| Requisites |
|---|

| | |
|---|---|
| **Assessment Threshold** | Pass mark = 50%<br><br>30% threshold on Case Study and 30% threshold on Short Answer Tests |

## Module Content & Assessment

| Assessment Breakdown | % |
|---|---|
| Other Assessment(s) | 100.00% |

| Derogations from the General Assessment Regulations |
|---|
| Pass mark = 50% |

## Assessments

| Other Assessment(s) | | | |
|---|---|---|---|
| **Assessment Type** | Case Study | **% of Total Mark for Module** | 40 |
| **Indicative Week** | See Student Handbook | **Learning Outcomes** | 1,2,3,4,5,6,7 |
| **Assessment Threshold:** | 30 | **Assessment Role** | Not yet determined |
| **Assessment Authenticity** | Not Online | **Pass/Fail** | No |
| **Assessment Description**<br>Case Study applying the methods to a dataset. | | | |
| **Assessment Type** | Online Quiz | **% of Total Mark for Module** | 20 |
| **Indicative Week** | See Student Handbook | **Learning Outcomes** | 1,2,3,4,5,6,7 |
| **Assessment Threshold:** | None | **Assessment Role** | Not yet determined |
| **Assessment Authenticity** | Online | **Pass/Fail** | No |
| **Assessment Description**<br>Ongoing online Multiple Choice quizzes | | | |
| **Assessment Type** | Short Answer Test | **% of Total Mark for Module** | 40 |

| | | | |
|---|---|---|---|
| **Indicative Week** | See Student Handbook | **Learning Outcomes** | 1,2,3,4,5,6,7 |
| **Assessment Threshold:** | 30 | **Assessment Role** | Not yet determined |
| **Assessment Authenticity** | Online | **Pass/Fail** | No |

**Assessment Description**
Two short answers tests covering the calculations and theory of the module.

## Module Activity

| **Full Time hours per semester** | |
|---|---|
| *Activity Type* | *Duration (Hours)* |
| Lecture | 39 |
| Self Directed | 161 |
| Hours (up to 100 for 5 ECTS credits) | 200.00 |

## Recommended Reading List

*Recommended Book Resources*

**Roxy Peck,Jay L. Devore. (2012), Statistics, Brooks/Cole, [ISBN: 9780840068590].**

**David Collett. (2002), Modelling Binary Data, Second Edition, CRC Press, p.408, [ISBN: 1584883243].**

*Supplementary Book Resources*

**Peter Dalgaard. (2008), Introductory Statistics with R, 2nd. Springer Science & Business Media, [ISBN: 9780387790541].**

**Gareth James,Daniela Witten,Trevor Hastie,Robert Tibshirani. (2021), An Introduction to Statistical Learning, 2nd. Springer, [ISBN: 9781071614174].**

**Roxy Peck,Chris Olsen,Tom Short. (2018), Introduction to Statistics and Data Analysis, 6th. Cengage Learning, [ISBN: 9781337793612].**

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# MATH 9902: Statistical Programming and Applications

## Module Details

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|---|---|
| **Module Code:** | MATH 9902 |
| **Module Long Title:** | Statistical Programming and Applications APPROVED |
| **Banner Title:** | Statistical Prog & Application |
| **Version:** | 2 |
| **Indicative NFQ level:** | Level 9 |
| **Valid From:** | Sept 2022 ( September 2022 ) |
| **Language of Instruction:** | English |
| **ECTS Credits::** | 5 |
| **Current Coordinator::** | CARL SULLIVAN |
| **Module Coordinators:** | • ALBERTO CAIMO ( 04 May 2022 to 08 April 2024 )<br>• CARL SULLIVAN ( 08 April 2024 to --- ) |
| **School Responsible:** | School of Mathematics & Statistics |
| **Campus:** | City Campus |
| **Module Overview** | This module introduces students to the computer laboratory and statistical applications and which will support their learning during their programme of study. The module does not assume any experience of programming or statistical software packages and allows learners to become accustomed to the online learning platform of the University, the ICT resources of the School and the software that will be used in their modules (e.g. R). The module is practical and allows students to learn at their own pace. |
| **Learning and Teaching Methods** | A mix of live online software sessions supported by software development environment tools and pre-recorded video lectures. |

| **Indicative Syllabus** |
|---|
| **1. Data Set Review**<br>1.1) Assessing data relevance, determine if correct data is available, in an appropriate format and if the data set is representative. Recognising how and when to resolve inconsistencies in a data set using expert knowledge. |
| **2. Probability Calculations**<br>2.1) Perform probability calculations using logical operators. |
| **3. Descriptive Statistics & Graphing**<br>3.1) Describe a data set using descriptive statistics and standard graphical techniques. |
| **4. Recode/Create Variables**<br>4.1) Assess the number of attribute values, recode new variables from existing variables, categorise variables, create new variables using binning, clustering or aggregating existing variables. |
| **5. Probability Distributions**<br>5.1) Describe a data set using probability distributions. |

| |
|---|
| **6. Statistical Data Analysis**<br>6.1) Design and conduct a statistical analysis on a data set. |
| **7. Simulation**<br>7.1) Design statistical experiments using simulation methods. |
| **8. Regression Modelling**<br>8.1) Build regression models. |

| Learning Outcomes | |
|---|---|
| *Upon successful completion of this module the learner will be able to* | |
| **#** | |
| MLO1 | Develop learning and expertise of a statistical software packages. |
| MLO2 | Access online support and help systems. |
| MLO3 | Assess data relevance for a specific task. |
| MLO4 | Recognise variables with outliers or missing values. |
| MLO5 | Validate and clean variable formats. |
| MLO6 | Visualise and summaries data. |
| MLO7 | Parametrically describe data using discrete and continuous distributions. |
| MLO8 | Conduct and interpret statistical analysis. |
| MLO9 | Build regression models. |

**Requisites**

## Module Content & Assessment

| Assessment Breakdown | % |
|---|---|
| Other Assessment(s) | 100.00% |

**Derogations from the General Assessment Regulations**

Pass mark = 50%

## Assessments

**Other Assessment(s)**

| | | | |
|---|---|---|---|
| **Assessment Type** | Case Study | **% of Total Mark for Module** | 80 |
| **Indicative Week** | See Student Handbook | **Learning Outcomes** | 1,2,3,4,5,6,7,8,9 |
| **Assessment Threshold:** | None | **Assessment Role** | Individual |
| **Assessment Authenticity** | Not Online | **Pass/Fail** | No |

**Assessment Description**
Case studies x 2

| | | | |
|---|---|---|---|
| **Assessment Type** | Multiple Choice Questionnaires | **% of Total Mark for Module** | 20 |
| **Indicative Week** | See Student Handbook | **Learning Outcomes** | 1,2,3,4,5,6,7,8,9 |
| **Assessment Threshold:** | None | **Assessment Role** | Individual |
| **Assessment Authenticity** | Online | **Pass/Fail** | No |

**Assessment Description**
Online quizzes

## Module Activity

| Full Time hours per semester | |
|---|---|
| *Activity Type* | *Duration (Hours)* |
| Lecture | 39 |
| Self Directed | 61 |
| Hours (up to 100 for 5 ECTS credits) | 100.00 |

## Recommended Reading List

*Recommended Book Resources*

**Mark Gardener. (2012), Beginning R, John Wiley & Sons, [ISBN: 9781118164303].**

**Paul Teetor. (2011), R Cookbook, Farnham: O'Reilly, [ISBN: 9780596809157].**

*Supplementary Book Resources*

**James T. McClave,P. George Benson,Terry T Sincich. (2018), Statistics for Business and Economics, Global Edition, Pearson Higher Ed, [ISBN: 9781292227078].**

**Joseph Adler. (2012), R in a Nutshell, O'Reilly Media, Inc., [ISBN: 9781449312084].**

*Other Resources*

**Website, Robert I. Kabacoff. (2017), Quick R by datacamp, http://www.statmethods.net/**

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# MATH 9903: Linear & Generalised Linear Regression Models

## Module Details

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|---|---|
| **Module Code:** | MATH 9903 |
| **Module Long Title:** | Linear & Generalised Linear Regression Models APPROVED |
| **Banner Title:** | MATH 9903 Linear & Generalised |
| **Version:** | 2 |
| **Indicative NFQ level:** | Level 9 |
| **Valid From:** | Sept 2022 ( September 2022 ) |
| **Language of Instruction:** | English |
| **ECTS Credits::** | 7.5 |
| **Current Coordinator::** | JOE CONDON |
| **Module Coordinators:** | JOE CONDON ( 07 April 2022 to --- ) |
| **School Responsible:** | School of Mathematics & Statistics |
| **Campus:** | City Campus |
| **Module Overview** | The aim of this module is to introduce the student to the multiple linear and generalised linear regression models – the most widely used models in data analysis. Model formulation and interpretation will be explored in detail, including inclusion of categorical predictors and interactions.<br><br>Model building/identification techniques are critically examined. Methods for residual and influence diagnostics are covered. The R software system (or equivalent) will be utilised by the student as a tool for fitting these models |
| **Indicative Syllabus** | Multiple Regression Model<br><br>Motivation and formulation of the multiple regression model. Variance of parameter estimates and fitted values, confidence intervals and hypothesis testing. General linear hypotheses and ANOVA. Including categorical predictors in regression.<br><br>Model Building/Identification & model diagnostics.<br><br>Model building techniques, residuals and model diagnostics and their role in model appraisal.<br><br>Generalised Linear models: logistic & Poisson Regression<br><br>Logistic and Poisson regression models. Fitting GLMs with software. Interpretation of model parameters and other model output. General linear hypotheses of parameters. Wald's and likelihood ratio tests. Model building techniques. |
| **Learning and Teaching Methods** | A mix of live online classes, pre-recorded video lectures and live online software sessions. |

Module MATH 9903 - Linear & Generalised Linear Regression Models v2 (Year/Cycle:1 / Semester:Semester 2 / Delivery Type:Mandatory)

| Learning Outcomes | |
|---|---|
| *Upon successful completion of this module the learner will be able to* | |
| **#** | |
| MLO1 | Formulate, fit and interpret the output from multiple regression models. |
| MLO2 | Include categorical predictors in regression models, with and without interactions and formulate classical ANOVA models in the multiple regression framework. |
| MLO3 | Use model building techniques to identify candidate models, including hypothesis testing and information criteria approaches. |
| MLO4 | Perform model critiques using regression and influence diagnostics. |
| MLO5 | Formulate, fit and interpret the output from generalised linear models (GLM: in particular logistic and Poisson regression). |
| MLO6 | Use model building techniques to identify candidate GLM models, including hypothesis testing and information criteria approaches. |

| Requisites | |
|---|---|
| **Assessment Threshold** | Data Analysis Reports: Threshold = 30%<br><br>Short questions/MCQ: Threshold = 30% |

## Module Content & Assessment

| Assessment Breakdown | % |
|---|---|
| Other Assessment(s) | 100.00% |

### Assessments

**Other Assessment(s)**

| | | | |
|---|---|---|---|
| **Assessment Type** | Report | **% of Total Mark for Module** | 60 |
| **Indicative Week** | See Student Handbook | **Learning Outcomes** | 1,2,3,4,5,6 |
| **Assessment Threshold:** | 35 | **Assessment Role** | Individual |
| **Assessment Authenticity** | Not Online | **Pass/Fail** | No |

**Assessment Description**
Data Analysis Report

| | | | |
|---|---|---|---|
| **Assessment Type** | Short Answer Test | **% of Total Mark for Module** | 40 |
| **Indicative Week** | See Student Handbook | **Learning Outcomes** | 1,2,3,4,5,6 |
| **Assessment Threshold:** | 35 | **Assessment Role** | Individual |
| **Assessment Authenticity** | Online | **Pass/Fail** | No |

**Assessment Description**
Short questions/MCQ.

## Module Activity

| Full Time hours per semester | |
|---|---|
| *Activity Type* | *Duration (Hours)* |
| Lecture | 39 |
| Self Directed | 111 |
| Hours (up to 100 for 5 ECTS credits) | 150.00 |

## Recommended Reading List

*Recommended Book Resources*

**Devore, J. L. and Peck, R.. (2005), Statistics: the exploration and analysis of data, Thomson/Brooks/Cole, Pacific Grove.**

**James T. McClave,P. George Benson,Terry Sincich. (2011), Statistics for Business and Economics, 11. Harlow: Pearson Education, Upper Saddle River, [ISBN: 9780321640116].**

**David Collett. (2002), Modelling Binary Data, Second Edition, CRC Press, Boca Raton, p.406, [ISBN: 1584883243].**

**Annette J. Dobson,Adrian G. Barnett. (2018), An Introduction to Generalized Linear Models, Chapman & Hall/CRC, p.376, [ISBN: 9781138741515].**

*Supplementary Book Resources*

**Frank Owen,Ron Jones. (1994), Statistics, Ft Press, p.529, [ISBN: 0273603205].**

**Harold J. Larson. (1974), Introduction to Probability Theory and Statistical Inference, John Wiley & Sons, p.450, [ISBN: 9780471517818].**

**Geoffrey Grimmett,David Stirzaker. (2001), Probability and Random Processes, Oxford University Press, p.626, [ISBN: 0198572220].**

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# MATH 9904: Topics in Applied Statistics

## Module Details

| | |
|---|---|
| **Module Code:** | MATH 9904 |
| **Module Long Title:** | Topics in Applied Statistics APPROVED |
| **Banner Title:** | Topics in Applied Statistics |
| **Version:** | 3 |
| **Indicative NFQ level:** | Level 9 |
| **Valid From:** | Sept 2025 ( September 2025 ) |
| **Language of Instruction:** | English |
| **ECTS Credits::** | 7.5 |
| **Current Coordinator::** | Michael Mcauley |
| **Module Coordinators:** | Michael Mcauley ( 19 June 2025 to --- ) |
| **School Responsible:** | School of Mathematics & Statistics |
| **Campus:** | City Campus |
| **Module Overview** | The aim of this module is to introduce the student to a number of major topics in modern statistical methods. The student will gain experience of applying these methods to real datasets and experience of reporting their findings/conclusions. Statistical software (R or equivalent) will be used. |
| **Indicative Syllabus** | |
| **Learning and Teaching Methods** | A mix of live online classes and pre-recorded video lectures. |

| **Indicative Syllabus** |
|---|
| **1. OVERVIEW**<br>1.1) A number of discrete topics, typically three, will be covered of which the following are indicative: |
| **2. Classification**<br>2.1) Tree based methods. Assessing classification accuracy; confusion matrix, specificity, sensitivity, OC curve & AUC. Compared to logistic regression methods. |
| **3. Clustering**<br>3.1) Multidimensional scaling; Hierarchical methods/k-means, distribution and density based clustering. |
| **4. Factor analysis**<br>4.1) Covariance and correlation matrices; principle components; factor analysis. Rotation of factor scores; How many factors to include. |
| **5. Survival analysis**<br>5.1) Censoring and incomplete data; Survivor and hazard functions; Life-table and KM methods; Log rank and Wilcoxon tests; PH models with regression structure. |
| **6. Statistical network analysis** |

| |
|---|
| 6.1) Manipulating relational data; Descriptive analysis of network graph characteristics; Exponential-family network models; Network block models. |
| **7. Applied Bayesian data analysis**<br>7.1) Prior predictive checking; Probabilistic generative models; Predictive posterior distributions; Hypothesis testing; Model selection. |

Module MATH 9904 - Topics in Applied Statistics v3 (Year/Cycle:1 / Semester:Semester 2 / Delivery Type:Mandatory)

| Learning Outcomes | |
|---|---|
| *Upon successful completion of this module the learner will be able to* | |
| **#** | |
| MLO1 | Formulate, apply and interpret the output from a number of modern statistical methodologies. |
| MLO2 | Effectively report the findings from statistical data analysis. |
| MLO3 | Use up-to-date software for various statistical analyses (e.g. R). |
| MLO4 | Produce appropriately formatted output (including graphs) for the inclusion in data analysis reporting. |
| MLO5 | Implement and compare competing statistical approaches to data analysis. |

**Requisites**

## Module Content & Assessment

| Assessment Breakdown | % |
|---|---|
| Other Assessment(s) | 100.00% |

## Assessments

**Other Assessment(s)**

| | | | |
|---|---|---|---|
| **Assessment Type** | Report | **% of Total Mark for Module** | 100 |
| **Indicative Week** | See Student Handbook | **Learning Outcomes** | 1,2,3,4,5 |
| **Assessment Threshold:** | 50 | **Assessment Role** | Individual |
| **Assessment Authenticity** | Not Online | **Pass/Fail** | No |

**Assessment Description**
Continuous Assessment: a series of written data analysis reports (typically 2) and video presentation of an analysis which provides an overview of the approach and the results (typically 1).

## Module Activity

| Full Time hours per semester | |
|---|---|
| *Activity Type* | *Duration (Hours)* |
| Lecture | 39 |
| Self Directed | 61 |
| Hours (up to 100 for 5 ECTS credits) | 100.00 |

## Recommended Reading List

*Other Book Resources*

**John Verzani. (2014), Using R for Introductory Statistics, Second Edition, CRC Press, [ISBN: 9781466590731].**

**Sarah Baldock. (2014), Using R for Statistics, Apress, [ISBN: 9781484201404].**

**D. Collett. (1994), Modelling Survival Data in Medical Research, Chapman and Hall/CRC, [ISBN: 0412448807].**

**Paul Kline. (1994), An Easy Guide to Factor Analysis, Psychology Press, [ISBN: 9780415094900].**

*Other Article/Paper Resources*

**Therneau, T.M. and Atkinson, E.J.. (2013), An Introduction to Recursive Partitioning Using the RPART Routines, Mayo Foundation, Technical Report 61, http://www.mayo.edu/hsr/techrpt/61.pdf**